Karlsruhe Chart of the Nuclides Nuclear Data

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Joint Research Centre

Overview

Nuclide Charts

Karlsruhe Chart of Nuclides

Electronic Nuclide Charts in Nucleonica

Nuclear Data Search in Nucleonica

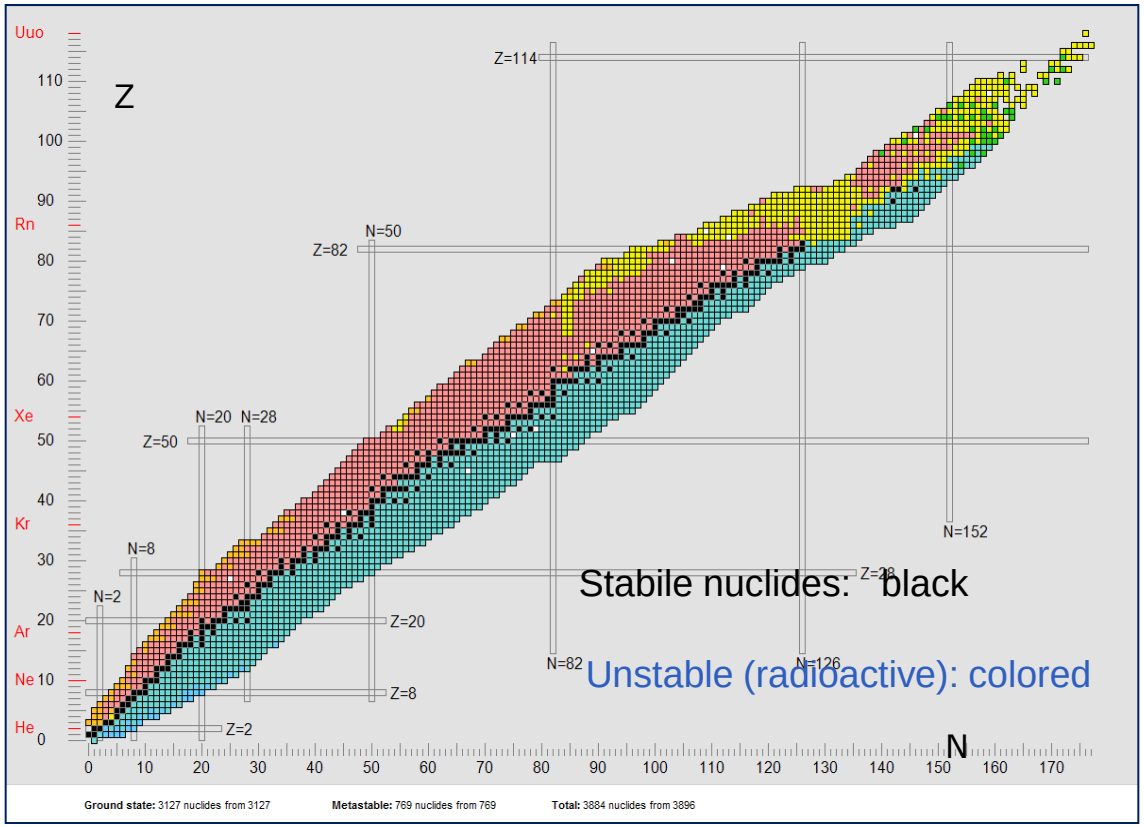
Fission Yields

What is a Nuclide Chart?

Nuclide charts are essentially a plot of the number of protons versus the number of neutrons in atomic nucleus.

Stable nuclides fall in a narrow range of neutron to proton ratio.

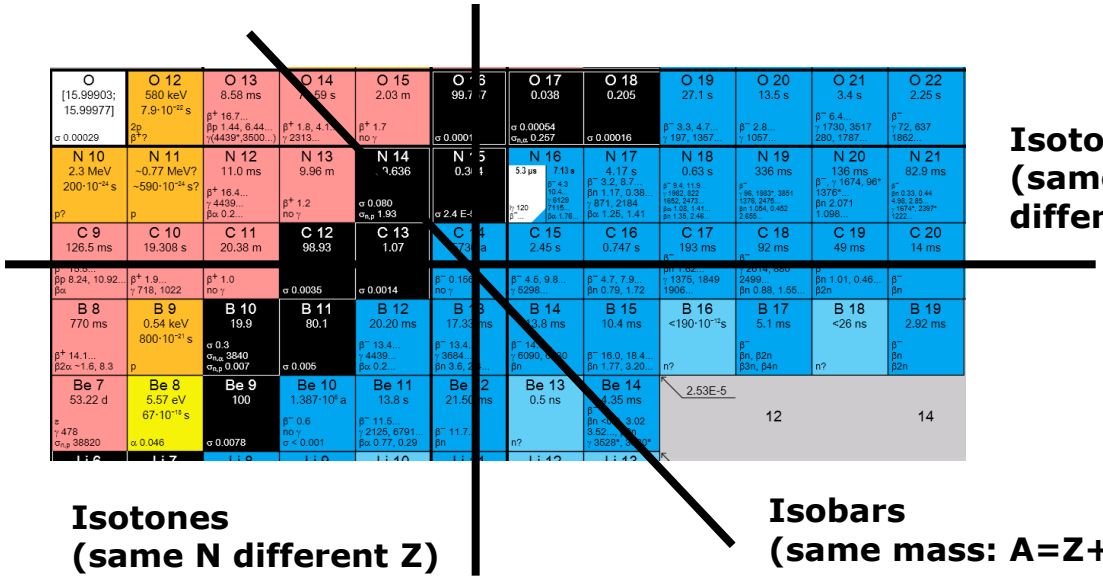
The stability of nuclei is extremely significant for special (magic) number of protons and neutrons.



Nuclide boxes

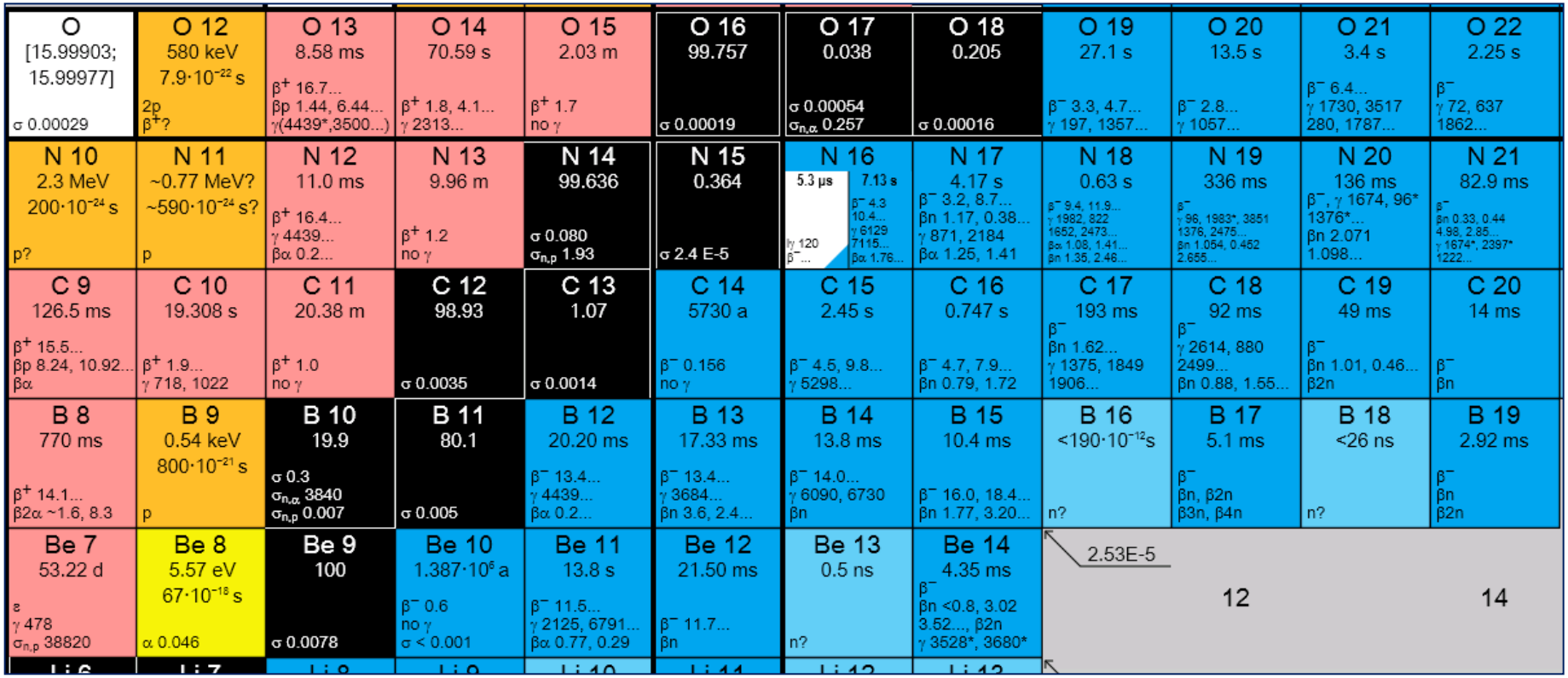
The charts contain information on the basic properties of known nuclides.

Each nuclide is represented by a box containing basic nuclear data



This data consists of the half-life, neutron cross sections, main gamma lines, etc… An important characteristic of the chart is the use of colours to denote the mode of decay, half-life, or cross-sections. If the nuclide has one or more meatstable states, the box is subdivided into smaller boxes for each state.

KNC – Colours of decay modes



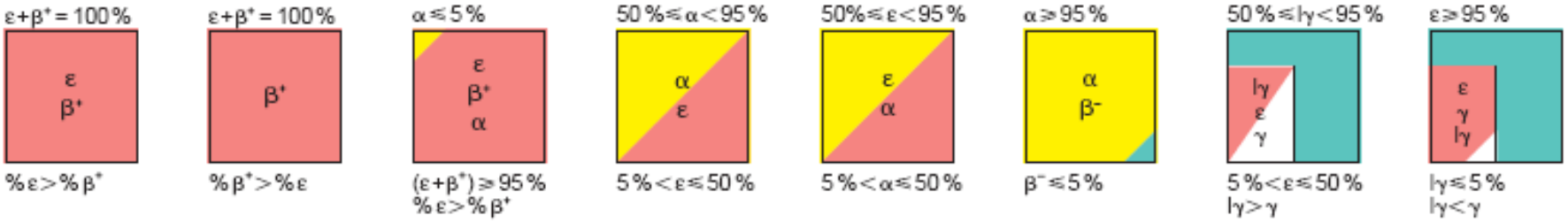
Chemical elements - white

Multiple decay modes
Large and small triangles

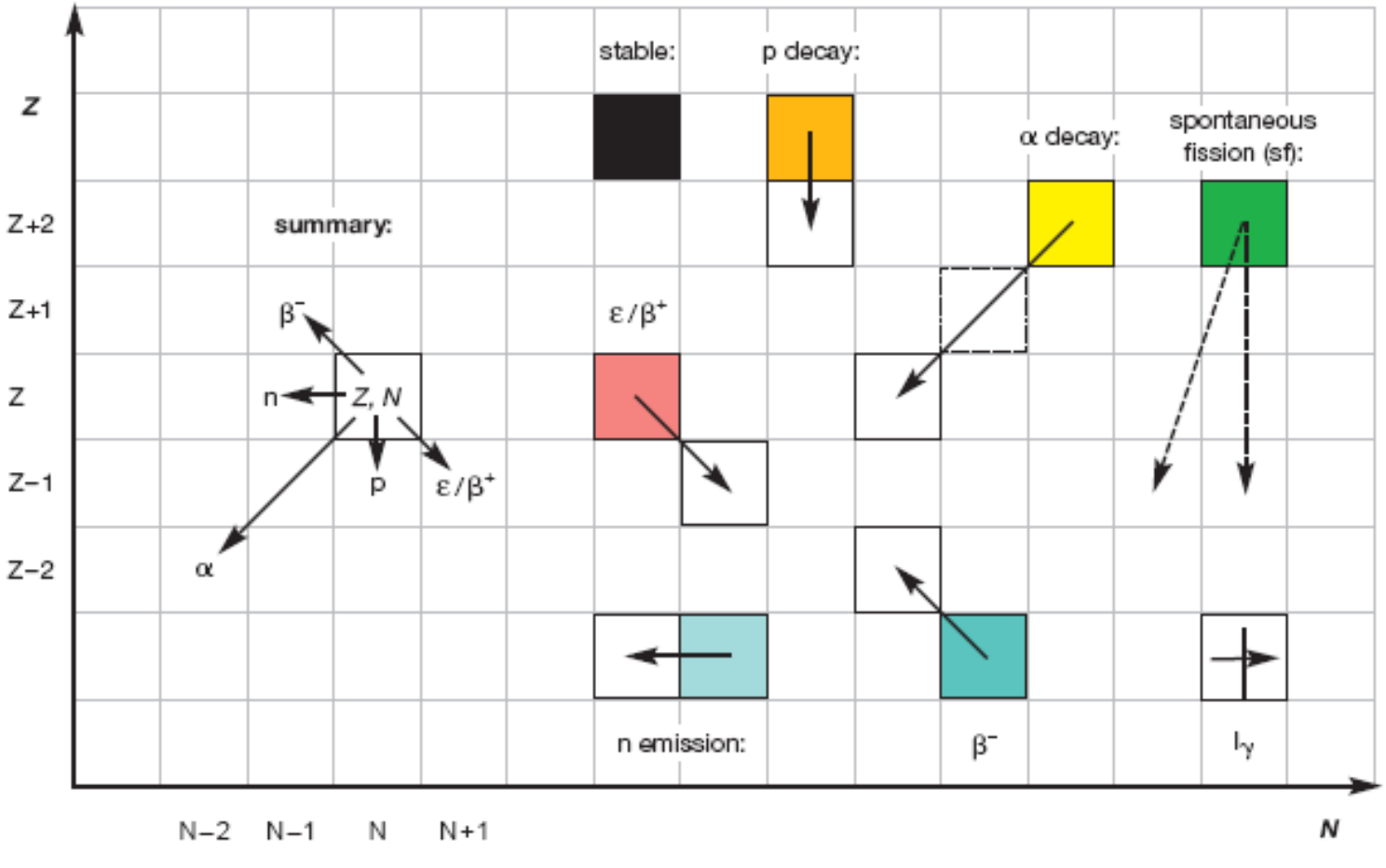
Po 210
138.38 d
α 5.30438...
γ (803)
σ < 0.0005 + < 0.030
$\sigma_{n,\alpha}$ 0.002
σ_f < 0.1

Cs 132
6.47 d
ε, β^+...
β^- 0.8...
γ 668, 465, 630..
$\sigma_{n,\alpha}$ < 0.15

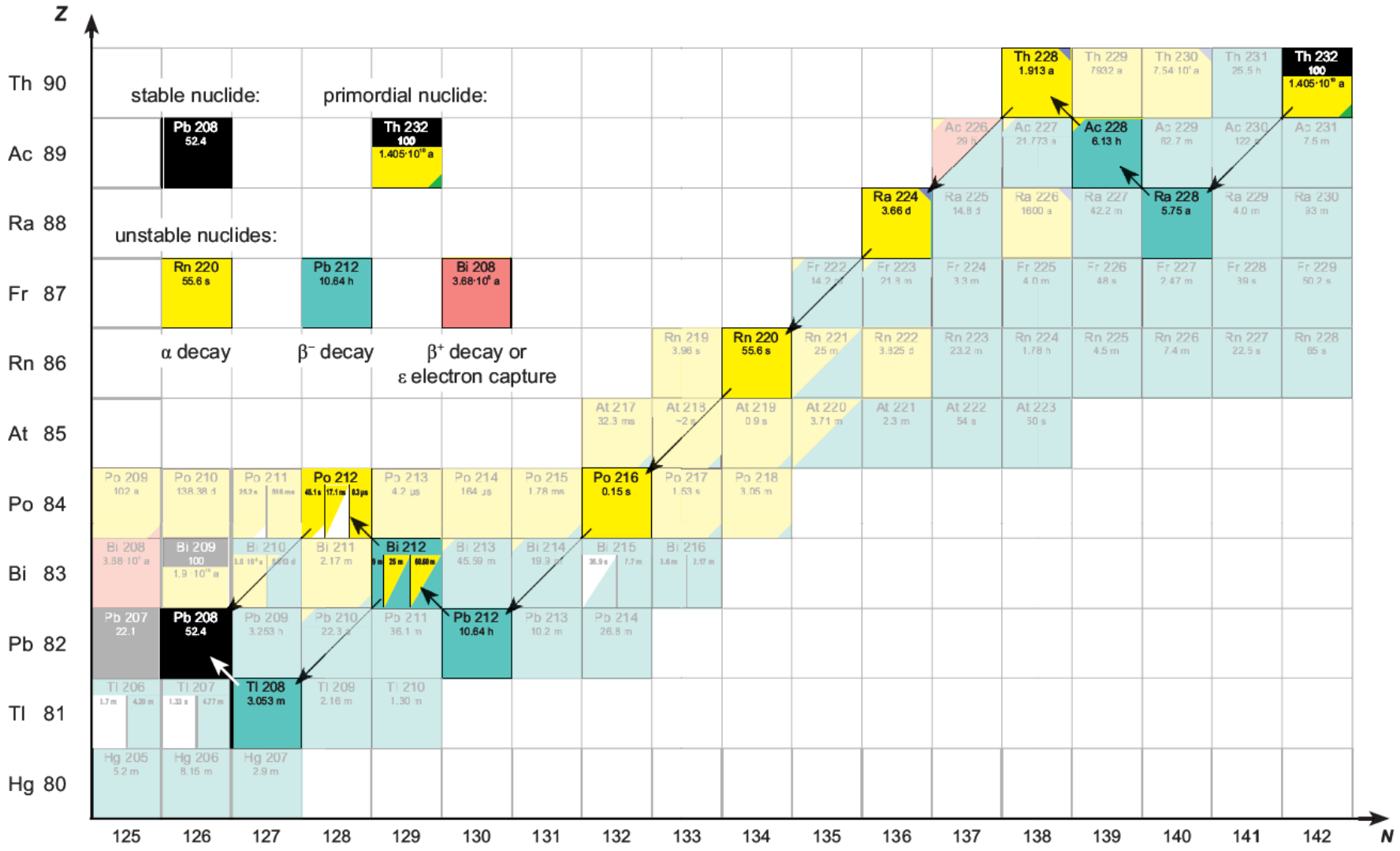
I 126
13.11 d
ε
β^- 0.9, 1.3...
β^+ 1.1...
γ 389, 666...
σ 5960



Decay processes on the KNC



Decay processes on the KNC



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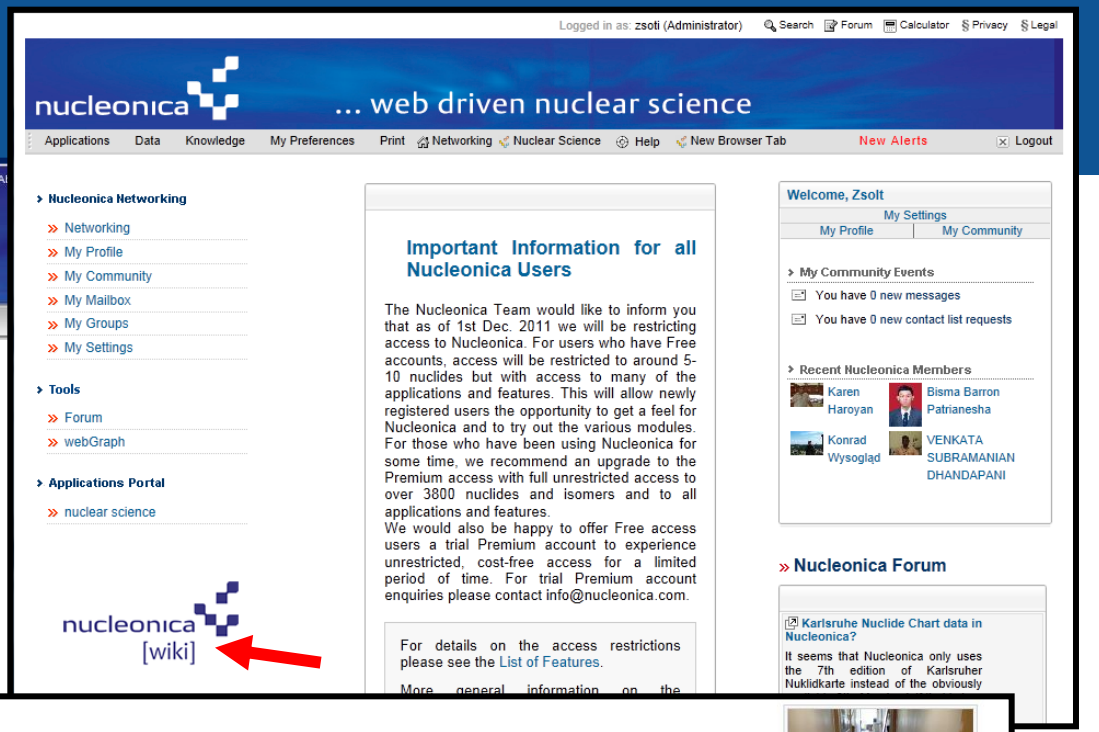
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Important Information for all Nucleonica Users
The Nucleonica Team would like to inform you that as of 1st Dec. 2011 we will be restricting access to Nucleonica. For users who have Free accounts, access will be restricted to around 5-10 nuclides but with access to many of the applications and features. This will allow newly registered users the opportunity to get a feel for Nucleonica and to try out the various modules. For those who have been using Nucleonica for some time, we recommend an upgrade to the Premium access with full unrestricted access to over 3800 nuclides and isomers and to all applications and features.
We would also be happy to offer Free access users a trial Premium account to experience unrestricted, cost-free access for a limited period of time. For trial Premium account enquiries please contact info@nucleonica.com.
For details on the access restrictions please see the List of Features.
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Karlsruhe Nuclide Chart data in Nucleonica?
It seems that Nucleonica only uses the 7th edition of Karlsruher Nuklidkarte instead of the obviously
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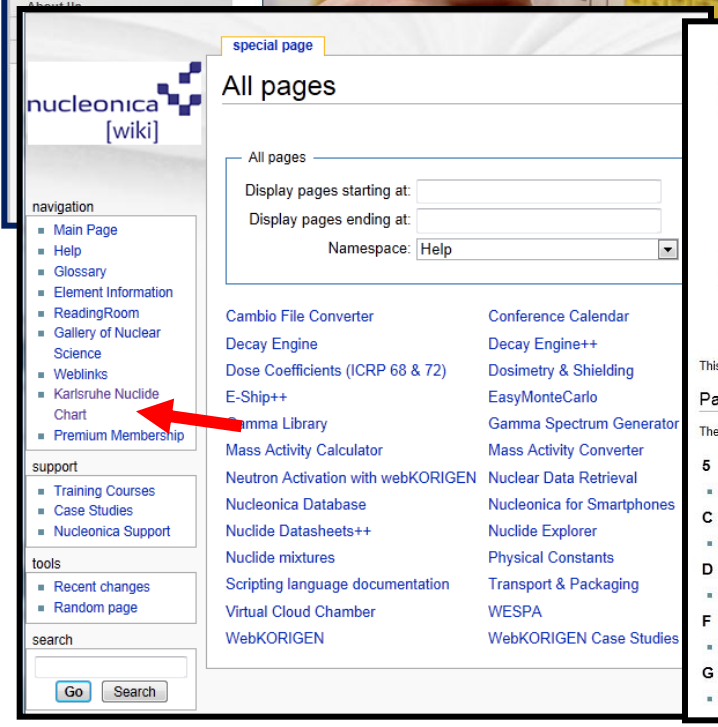
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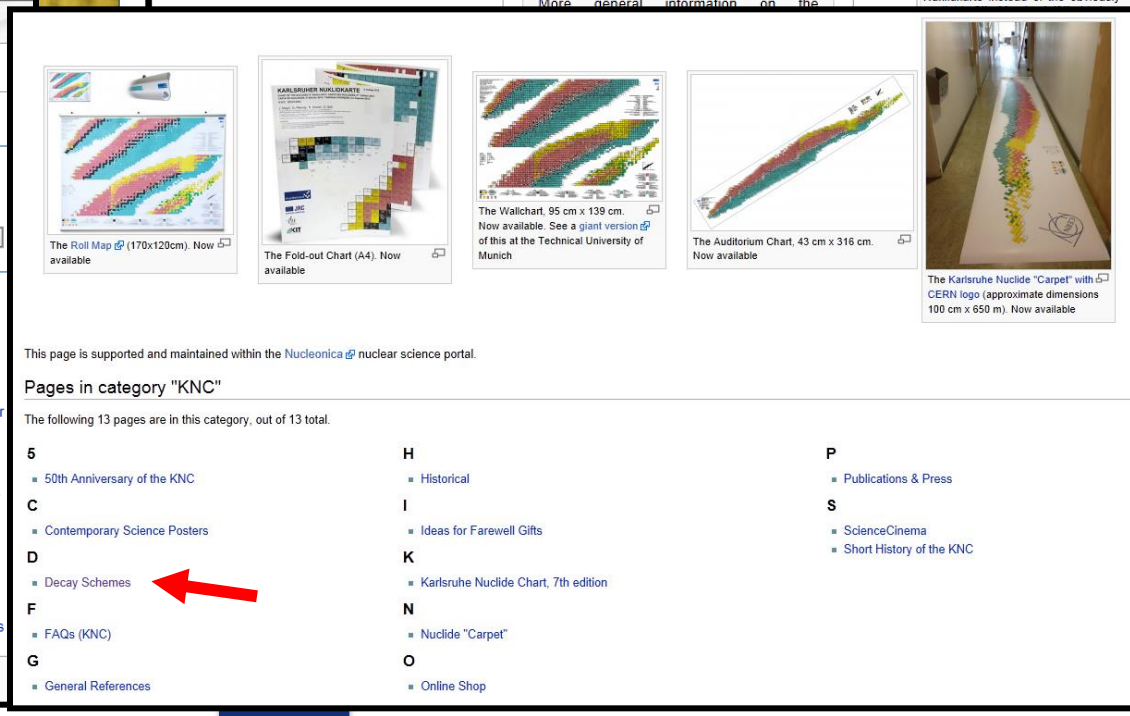
WebKORIGEN Case Studies


The Roll Map (170x120cm). Now available
The Fold-out Chart (A4). Now available
The Wallchart, 95 cm x 139 cm. Now available. See a giant version of this at the Technical University of Munich
The Auditorium Chart, 43 cm x 316 cm. Now available
The Karlsruhe Nuclide "Carpet" with CERN logo (approximate dimensions 100 cm x 650 m). Now available
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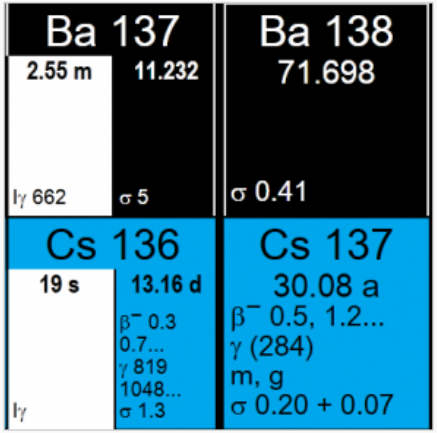
Pages in category "KNC"
The following 13 pages are in this category, out of 13 total.
5
50th Anniversary of the KNC
C
Contemporary Science Posters
D
Decay Schemes
F
FAQs (KNC)
G
General References
H
Historical
I
Ideas for Farewell Gifts
K
Karlsruhe Nuclide Chart, 7th edition
N
Nuclide "Carpet"
O
Online Shop
P
Publications & Press
S
ScienceCinema
Short History of the KNC

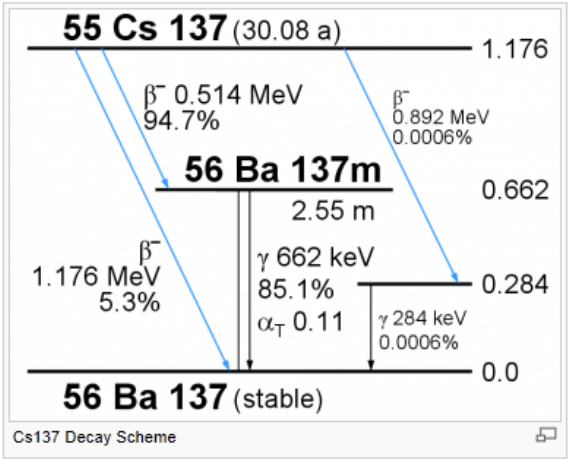
Decay Schemes

55 Cs 137 (Z=55, N=82)

The nuclide Cs 137 is an isotope of the element caesium (atomic number 55, chemical symbol Cs). There are 137 nucleons in the nucleus consisting of 55 protons and 82 neutrons. Cs 137 is radioactive with a half-life of 30.08 years.



Cs 137: Extract from the Karlsruhe Nuclide Chart, 8th Edition (2012)



Cs137 Decay Scheme

Main Radiations	Branching	E
β^-	0.947	0.514 MeV
$\gamma(ce)$	0.851	662 keV
β^-	0.053	1.176 MeV
β^-	0.0006	0.892 MeV
γ	0.0006	284 keV

The colour blue indicates that the nucleus decays by β^- emission. Cs 137 is characterised by the emission of several β^- particles with different endpoint energies. The most probable β– emission is at 0.5 MeV whereas the highest energy emission occurs at 1.2 MeV. Additional beta particles are also emitted indicated by the dots. The box entry m indicates that the main β– decay is to the metastable state (94.7%) Ba 137m.

The gamma transition from this metastable state is found in the nuclide box Ba 137m. The use of the symbol g indicates that the direct transition to the ground state has a branching greater than 5%. Actually in this case it is 5.3%. Decay to an excited state of the daughter Ba 137 is less probable (less than 1%) and gives rise to the weak gamma emission at 284 keV indicated by the entry (284).

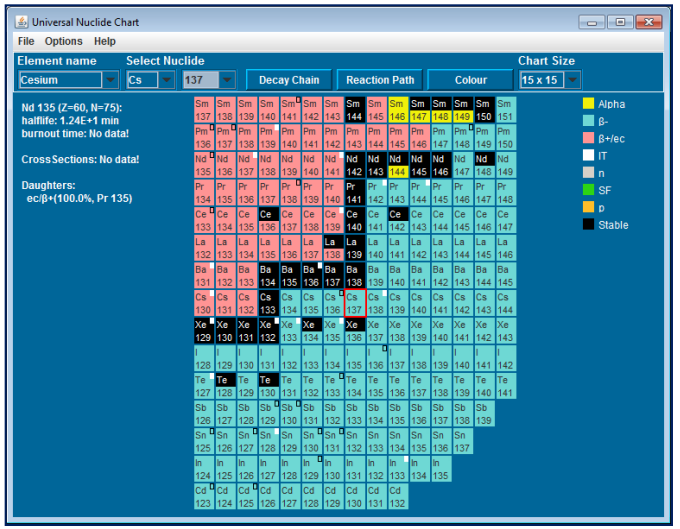
Neutron capture in Cs 137 leads to the formation of Cs 138m with a cross section of 0.20 barns, and to Cs 138g with a cross section of 0.07 barns

References

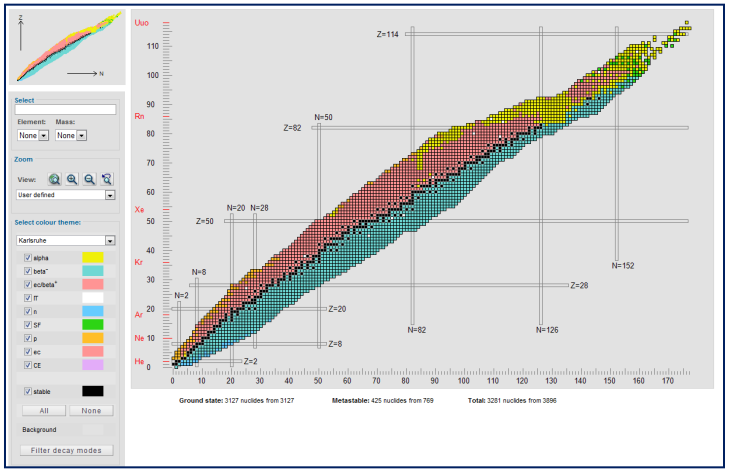
Half-life: 30.08(9) a, Nucl.Data Sheets 108(2007)2173

Electronic Nuclide Charts in Nucleonica

Universal Nuclide Chart
(UNC – decay chain simulator)



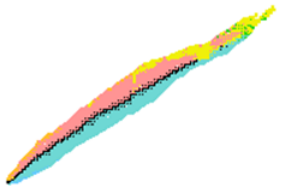
Nuclide Explorer
(connected with other
Nucleonica tools)



European Commission

Universal Nuclide Chart

› Nuclide Explorer



» Actual Chart: Karlsruhe

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Universal Nuclide Chart

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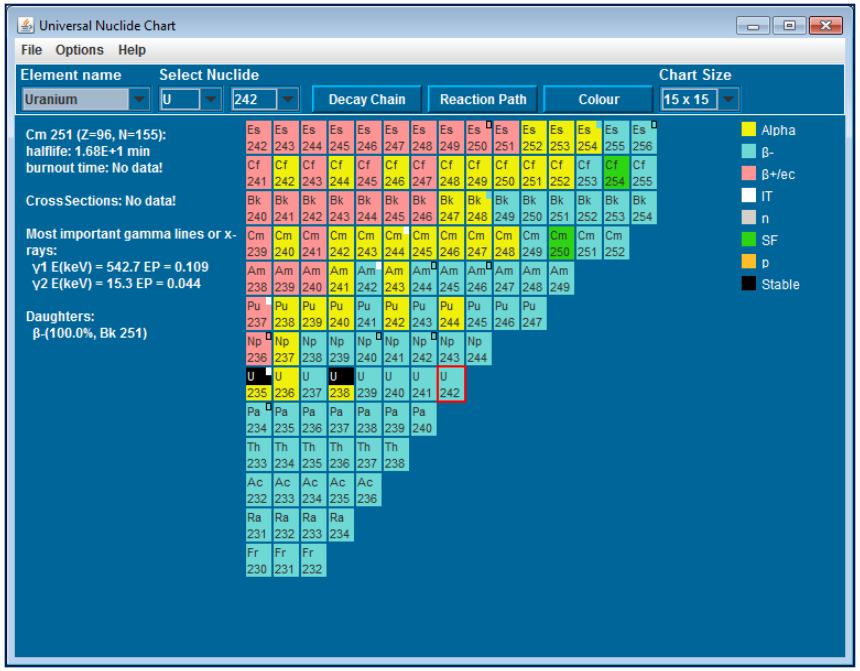
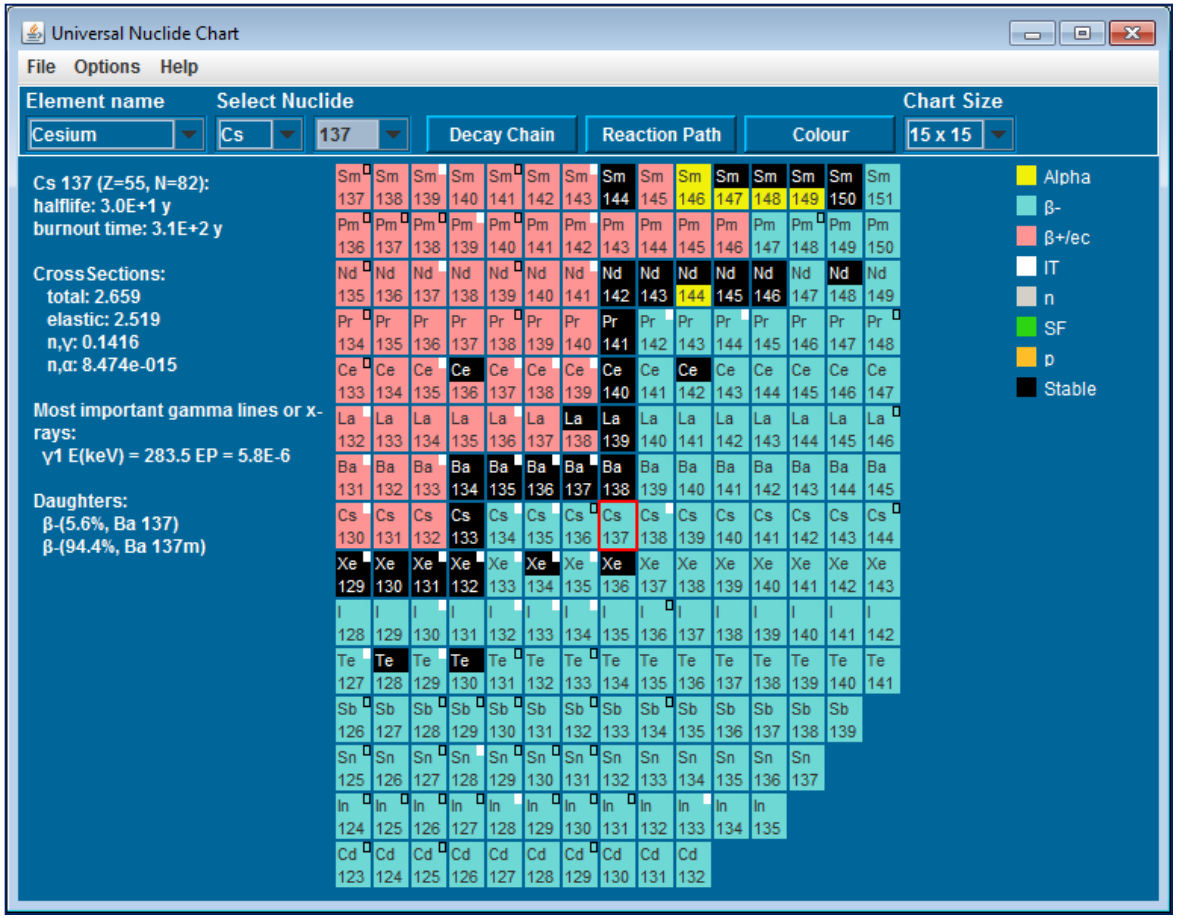


Nuclear Data in UNC



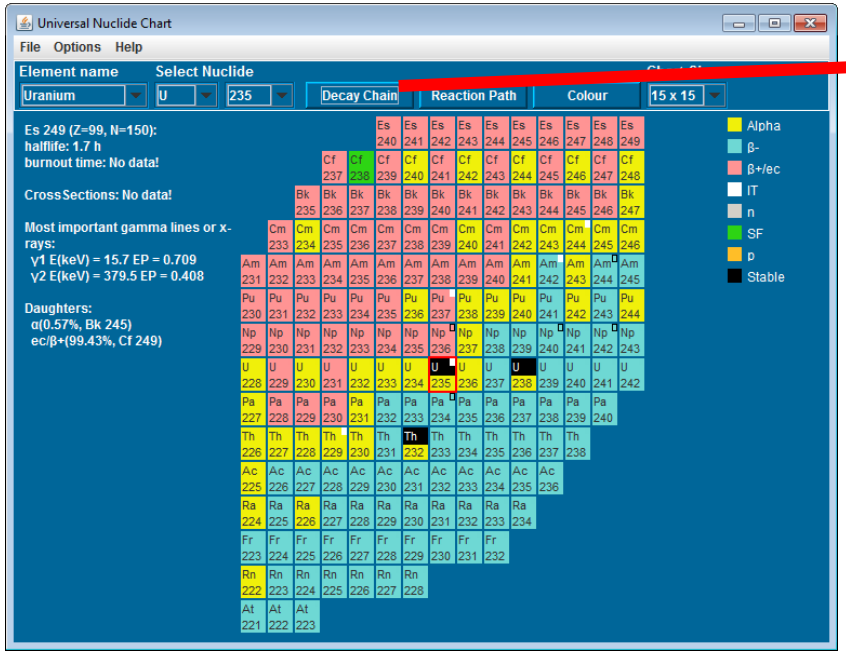
The Selected Nuclide is in the middle of the Chart

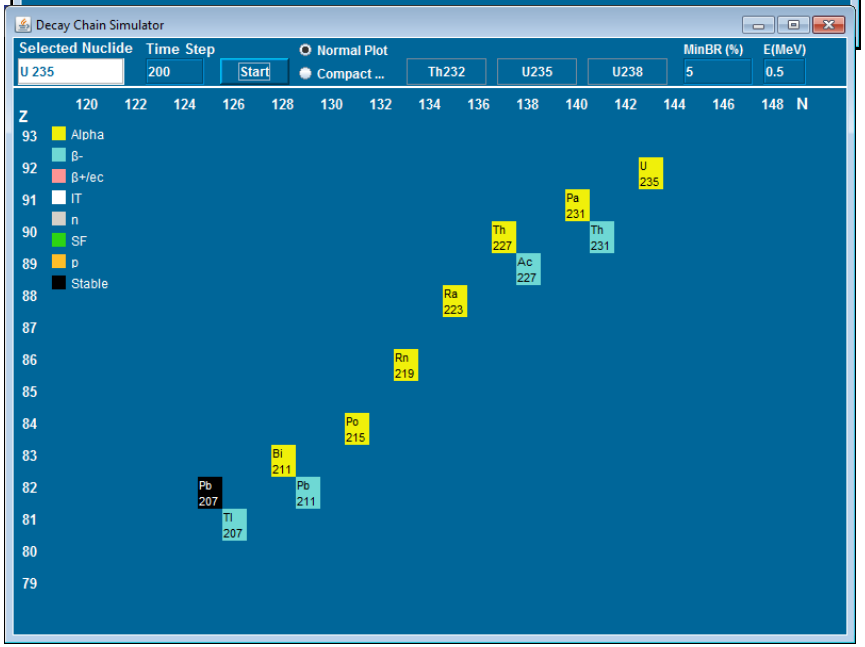
Mouse pointer:
For the pointed nuclide the most important nuclear data is shown on the left side

Decay Chain button

Reaction Path button

Decay chain of U-235



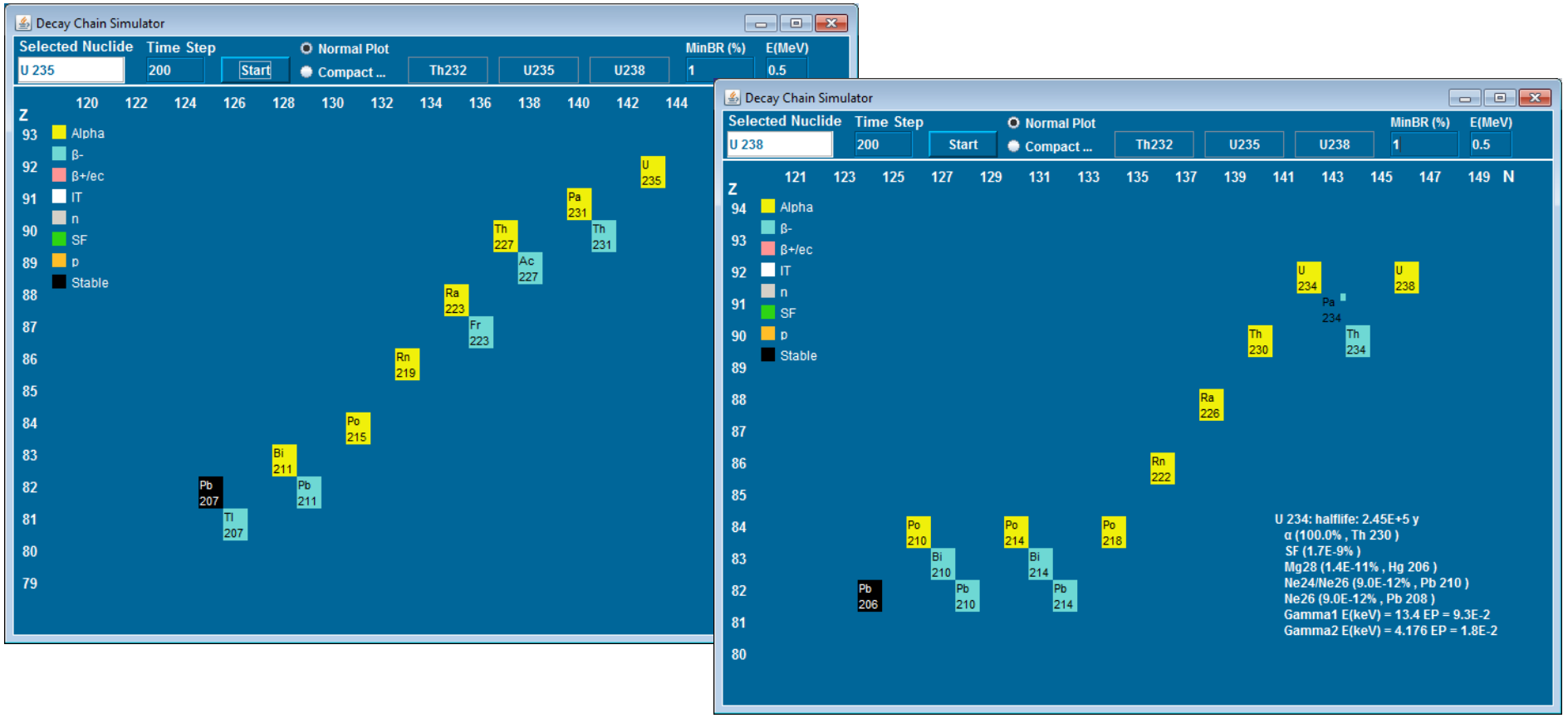


Set MinBr(%) to 5%: some decay path are not displayed anymore

E(MeV): causes blinking alarm on nuclides with higher:
gamma energy * emission probability

European Commission

Decay chains of U-235 and U-238



Exercises

Universal Nuclide Chart

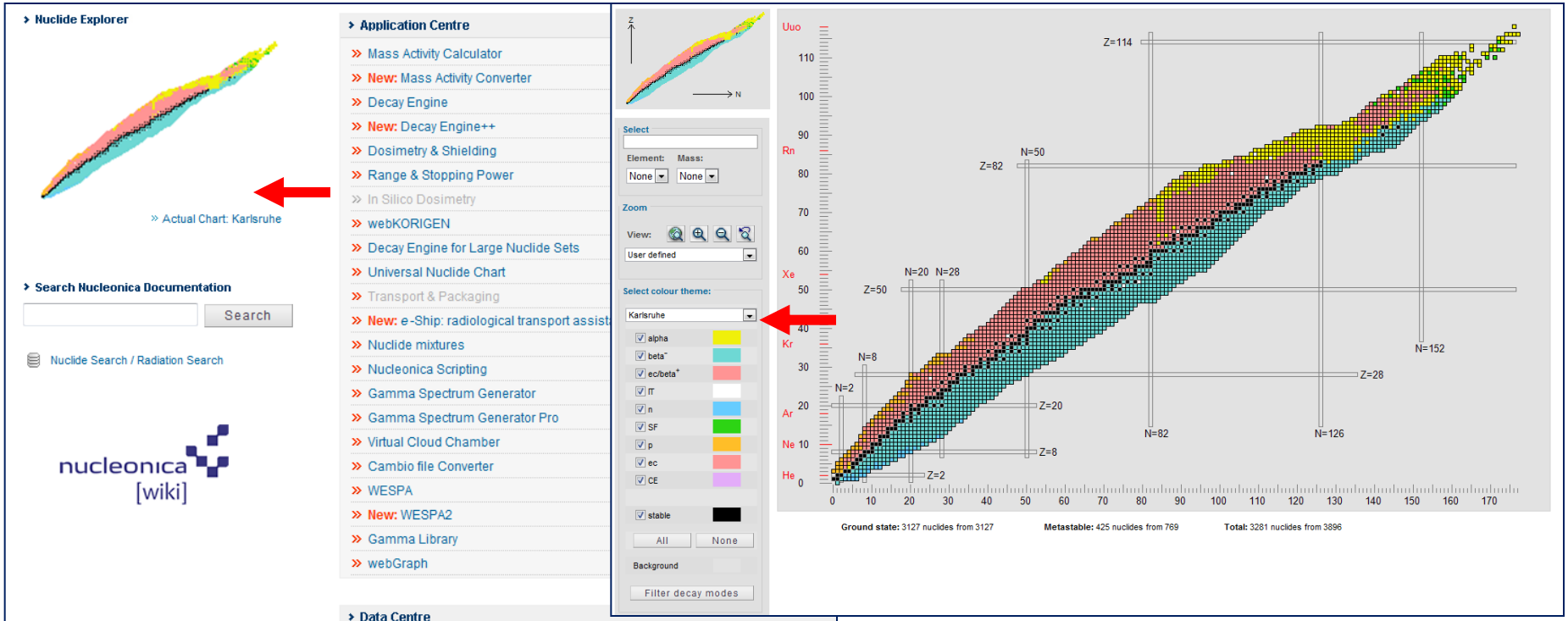
1. In the decay chain of U-238 find the nuclide which emits gamma photons with 1001 keV. (Pa-234m)

2. In the decay chain of U-235, Ac-227 has alpha decay with BR 1.38% to Fr-223. Switch of all decays from the display which have less than 2% branching ratio.(MinBR%=2)

3. Switch off the blinking of the Tl-208 on the decay chain of Th-232.

Nuclide Explorer

European Commission

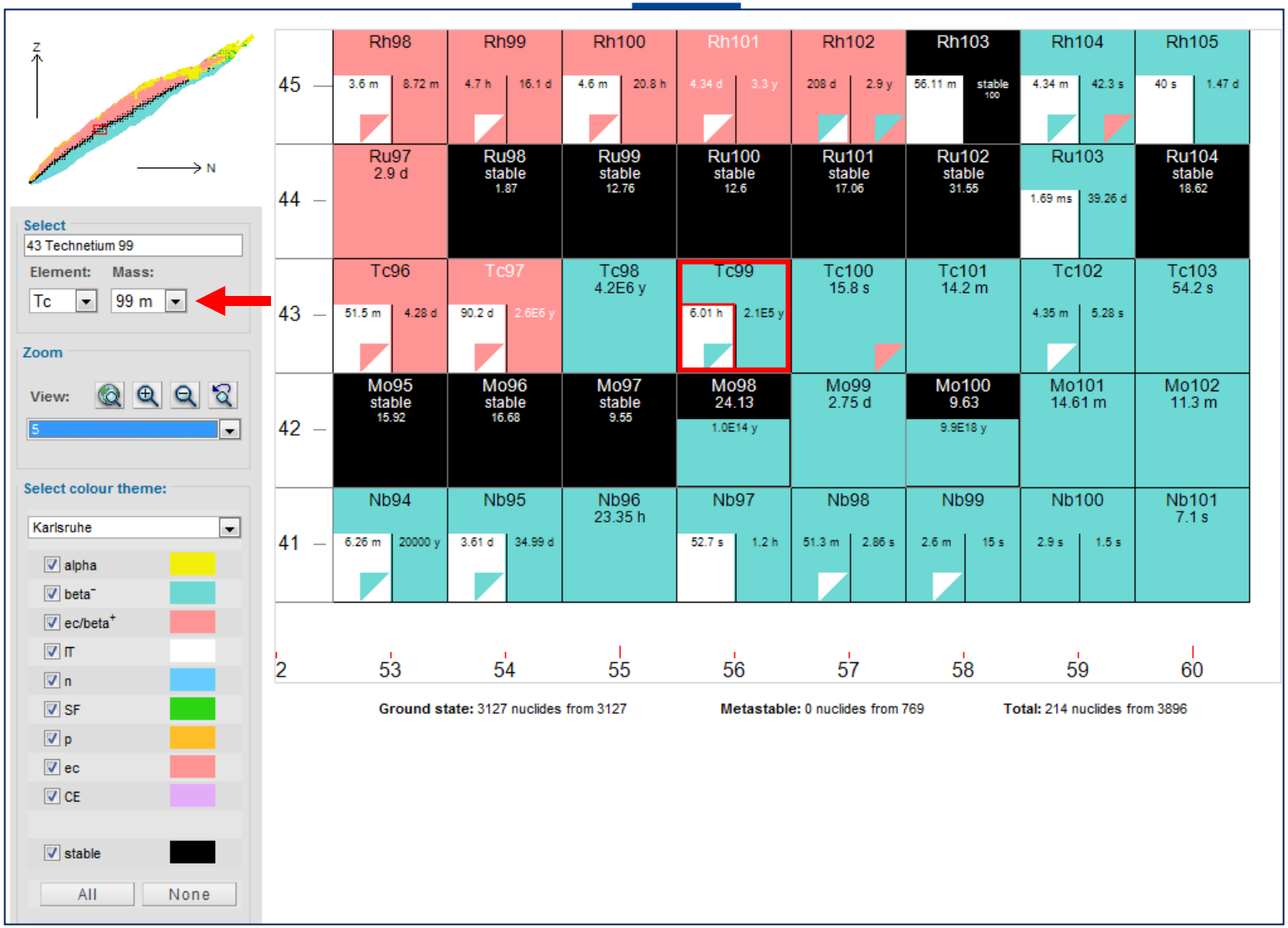


Colour scheme is changeable

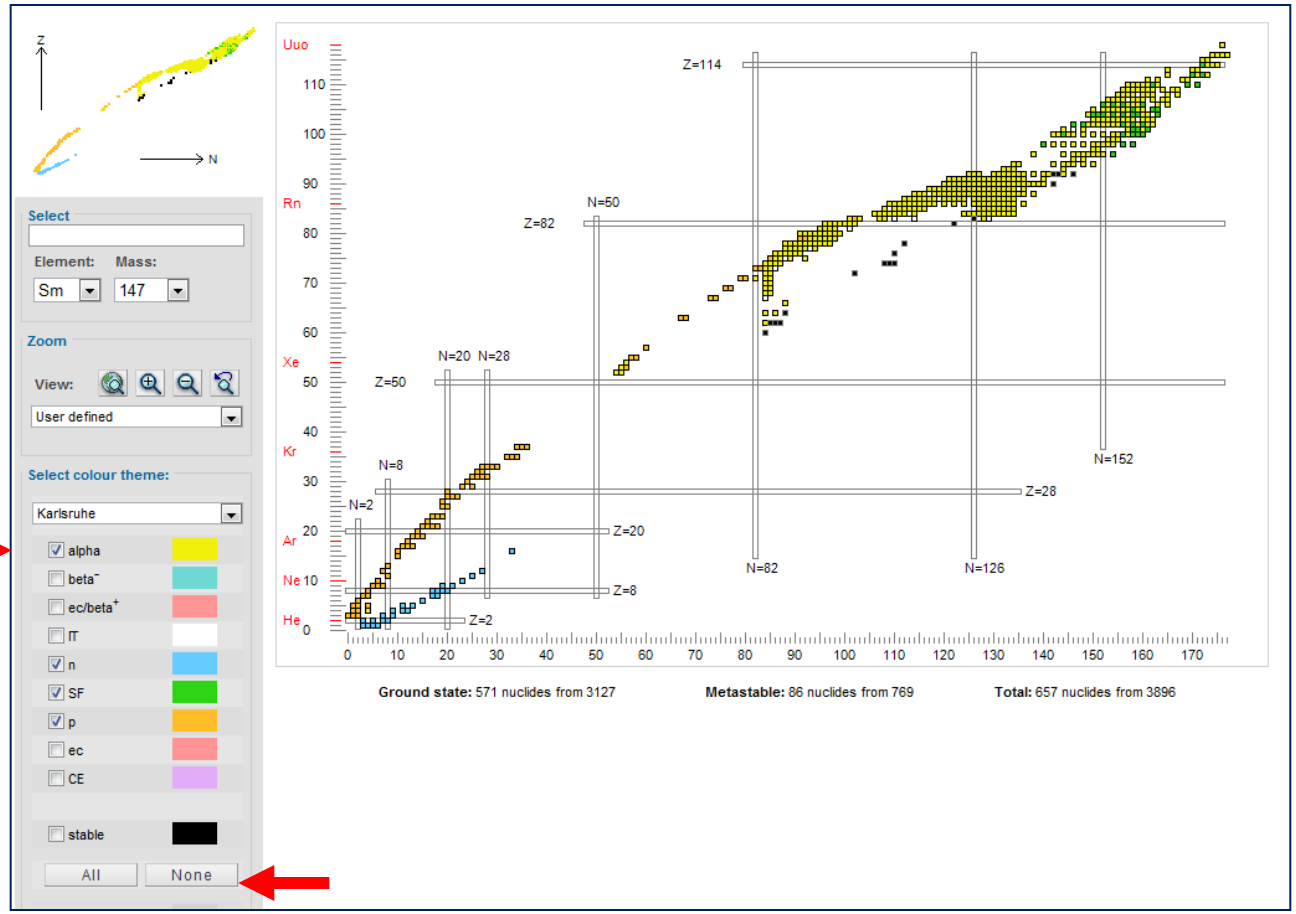
Decay modes can be filtered

Nuclide Tc-99m

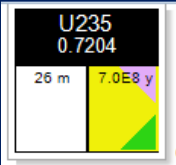
European Commission



Nuclides with alpha, p and n main decay modes and SF nuclides



Nuclide Data Sheets++



Nuclide Datasheets++

92 Uranium

Current Chart: Karlsruhe

Questions, remarks, suggestions

Nuclide selector

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Element U | Mass 235

Tabs

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» Nucleonica Databases

Nuclide	$^{235}_{92}U_{143}$		
Density	19.1 g/cm^3		
Mass Excess	40920.456 (± 1823) keV		
Atomic Mass	235.043929918 (± 1957) u		
Half-life	703.8 (± 5) My		
Spin	7/2 ħ		
Parity	-		
Binding Energy	7.59091 MeV/nucleon		
Abundance	0.7204 (± 6) atom %		
Effective Dose Coefficient Inhalation	8.5E-06 (Sv/Bq)		
Effective Dose Coefficient Ingestion	4.7E-08 (Sv/Bq)		
Mean Decay Energies			
Alpha	4.4646 (Mev)		
Electron	50.6717 (keV)		
Photon	163.616 (keV)		
Type of decay	**Branching Ratio**	**Decay Energy,Q**	**Daughters**
α	1	4.6787 (MeV)	90 Th 231
SF	7.2E-11	176.4 (MeV)	undefined
Ne20	8E-12	unknown	82 Pb 215
Ne25	8E-12	unknown	82 Pb 210
Mg28	8E-12	unknown	80 Hg 207
Type of parent decay	**Branching Ratio**	**Decay Energy,Q**	**Parents**
IT	1	7.68E-05 (MeV)	92 U 235m
ec	0.999985	0.1237 (MeV)	93 Np 235
α	0.0006	5.2445 (MeV)	94 Pu 239

Nuclide Data Sheets++

Co57
2.7E2 d

Nuclide Datasheets++

27 Cobalt

Current Chart: Karlsruhe

Element Mass

Co 57

Reference Data | Options | Radiations | Description | Derived Data | Cross S

» Nucleonica Databases

Nuclide	$^{57}_{27}Co_{30}$
Density	8.86 g/cm^3
Mass Excess	-59344.204 (± 713) keV
Atomic Mass	56.936291373 (± 765) u
Half-life	271.80 (± 5) d
Spin	7/2 ħ
Parity	-
Binding Energy	8.74186 MeV/nucleon
Abundance	-
Effective Dose Coefficient Inhalation	1E-09 (Sv/Bq)
Effective Dose Coefficient Ingestion	2.1E-10 (Sv/Bq)
Mean Decay Energies	
Alpha	0 (Mev)
Electron	18.2925 (keV)
Photon	125.216 (keV)

Type of decay	Branching Ratio	Decay Energy,Q	Daughters
ec	1	0.836 (MeV)	26 Fe 57
Type of parent decay	**Branching Ratio**	**Decay Energy,Q**	**Parents**
ec/β+	1	3.2642 (MeV)	28 Ni 57

Element Mass

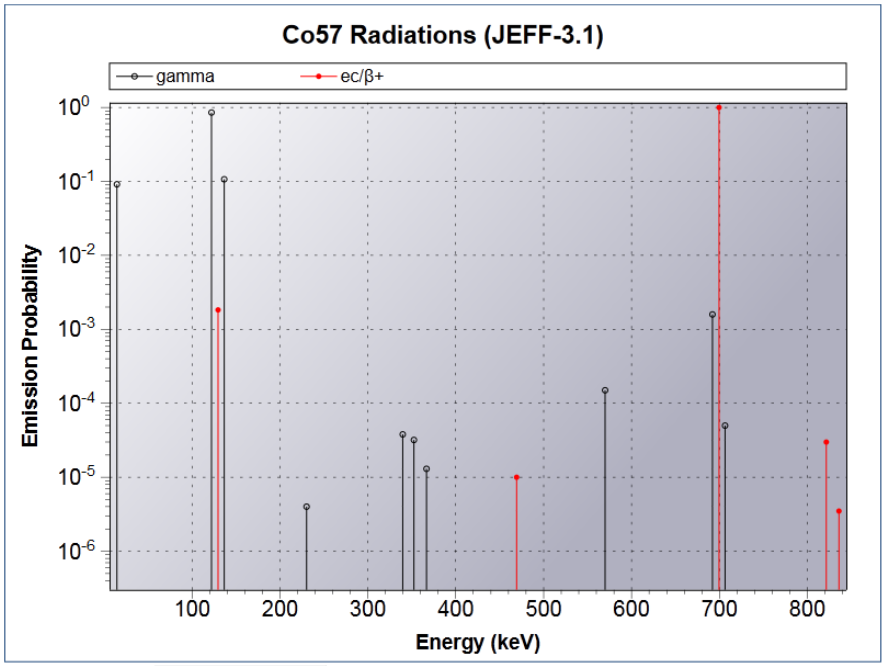
Co 57

CPU-Time / Total-Time: 1.8 / 2.9 sec

Reference Data | Options | Radiations | Description | Derived Data | Cross Sections | Prompt Gammas

JEFF-3.1 | 8th Table of Radioactive Isotopes

gamma | ec/beta+ | discrete e⁻ | X-rays & annihilation | Show details



Type	E (keV)	Emission probability
ec/β+	699.526	9.982e-1
γ	122.061	8.5510e-1
γ	136.474	1.071e-1
γ	14.413	9.15e-2
ec/β+	129.580	1.830e-3
γ	692.010	1.590e-3
γ	569.940	1.50e-4
γ	706.420	5.00e-5
γ	339.670	3.80e-5
γ	352.340	3.20e-5
ec/β+	821.587	3.0000e-5
γ	366.740	1.30e-5
ec/β+	469.260	1.0000e-5
γ	230.270	4.0e-6
ec/β+	836.000	3.5000e-6
2	15	

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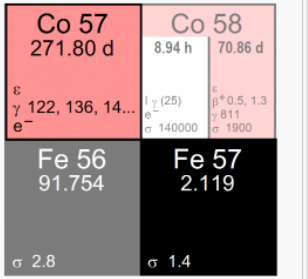
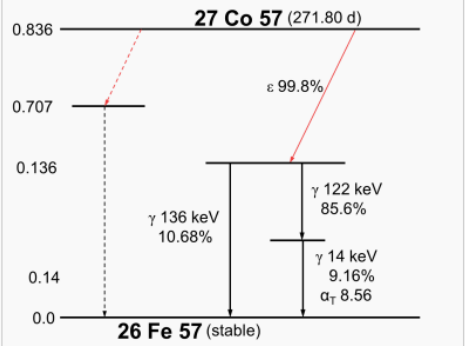


Co 57: Extract from the Karlsruhe Nuclide Chart



Co 57 Decay Scheme

Compare databases

	JEFF-3.1	ENDF/B-VII.1	Nubase 2003	Nubase 2012	ICRP-72
$^{57}_{27}Co_{30}$					
Density					
Mass Excess			-59344.204 (± 713) keV	-59344.948 (± 619) keV	
Atomic Mass			56.936291373 (± 765) u	56.936290574 (± 664) u	
Half-life	271.80 (± 5) d	271.74 (± 6) d	271.74 d 0.06	271.74 d 0.06	
Spin	7/2 ħ	7/2 ħ	7/2-	7/2-	
Parity	-	-			
Binding Energy			8.74186 MeV/nucleon	8.74187 MeV/nucleon	
Abundance			-	-	
Effective Dose Coefficient Inhalation					1E-09 (Sv/Bq)
Effective Dose Coefficient Ingestion					2.1E-10 (Sv/Bq)
Mean Decay Energies					
Alpha	0 (Mev)	0 MeV			
Electron	18.2925 (keV)	18.6615 keV			
Photon	125.216 (keV)	125.143 keV			
Decay					
Co57 (ec) 26 Fe 57 Branching ratio	1	1			
Decay Energy, Q	0.836 (MeV)	0.836 (MeV)			
Decay Production					
28 Ni 57 (ec/β+) Co57 Branching ratio	1	1			
Decay Energy, Q	3.2642 (MeV)	3.2622 (MeV)			

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$^{57}_{27}Co_{30}$ ◉ gamma ○ ec/beta$^+$ ○ discrete e$^-$ ○ X-rays & annihilation

Type	Energy(keV) JEFF-3.1	Energy(keV) ENDF/B-VII.1	Emission Probability JEFF-3.1	Emission Probability ENDF/B-VII.1
γ	122.061 (± 0.000)	122.0607 (± 0.0001)	8.5510e-1 (± 6.0e-4)	8.560e-1 (± 1.7e-3)
γ	136.474 (± 0.000)	136.4736 (± 0.0003)	1.071e-1 (± 1.5e-3)	1.0680e-1 (± 8.0e-4)
γ	14.413 (± 0.000)	14.4129 (± 0.0006)	9.15e-2 (± 1.7e-3)	9.16e-2 (± 1.5e-3)
γ	692.010 (± 0.020)	692.410 (± 0.070)	1.590e-3 (± 6.0e-5)	1.49e-3 (± 1.0e-4)
γ	569.940 (± 0.040)	570.090 (± 0.200)	1.50e-4 (± 2.0e-5)	1.580e-4 (± 1.0e-5)
γ	706.420 (± 0.020)	706.540 (± 0.220)	5.00e-5 (± 5.0e-6)	5.00e-5 (± 5.0e-6)
γ	339.670 (± 0.030)	339.690 (± 0.210)	3.80e-5 (± 4.0e-6)	3.70e-5 (± 3.0e-6)
γ	352.340 (± 0.020)	352.330 (± 0.210)	3.20e-5 (± 4.0e-6)	3.00e-5 (± 3.0e-6)
γ	366.740 (± 0.030)	366.800 (± 0.300)	1.30e-5 (± 4.0e-6)	1.20e-5 (± 3.0e-6)
γ	230.270 (± 0.030)	230.400 (± 0.400)	4.0e-6 (± 4.0e-6)	4.0e-6 (± 4.0e-6)

Reference Data | Options | Radiations

○ Nucleonica standard

◉ Compare Databases

- ☑ JEFF-3.1
- ☑ ENDF/B-VII.1
- ☑ Nubase 2003
- ☑ Nubase 2012
- ☑ ICRP 72
- ☐ Other

Exercises

Nuclide Explorer

1. Switch the colour scheme of Nuclide Explorer to Binding Energy scheme, after that to General Electric scheme and at the end switch it back to Karlsruhe colour scheme.

2. Switch off the colours of all radioactive nuclides. Switch on the colours after.

3. Select the Nuclide Cs 137 in View: Resolution 9.

Nuclide Data Sheets++

1. What are the daughters of Cs-137? What is the most important gamma line of Cs-137?(283.5 keV, EP=5.8E-6)

2. What is the daughter of Ba-137m? What is the most important gamma line of Ba-137m?(661 keV, EP=90.1%)

3. For the decay of Pu-239, what is the maximum alpha particle **energy**?(5.156 MeV)

Nuclide Data Search

European Commission

- Data Centre
  - Physical Constants
  - Nuclide Explorer
  - **New:** Nuclide Datasheets++ (Reference Data, Radiations, Derived Data, Cross Sections)
  - Nuclide Datasheets
  - **New:** Nuclide Search / Radiation Search
  - **New:** Dose Coefficients
  - Fission Yields
  - Universal Nuclide Chart

Nuclide Search / Radiation Search

Version: 201

Questions, remarks, suggestions can be post

Nuclide Search | Radiation Search | Advanced Search

Atomic number Z: Element: Bi

Mass number A: –

Half-life 1 d – 3 wk

Stable/Primordial Isomers Decay Mode

Search Clear

Table display options

Decay mode, Parity, Half-life, Daughter, Abundance, Branching Ratio, Spin, Q-Value

CPU time / Total time (sec): 0.39 / 1.4

Search returned 5 results, Number of nuclides: 3

Nuclides	Decay	Half-life	Abundance (atom %)	Spin (ħ)	Parity	Daughter	Branching ratio	Q-Value (MeV)
83 Bi 205	ec/β+	15.31 (± 4) d		9/2	-	82 Pb 205	0.858	2.7081
83 Bi 205	ec/β+	15.31 (± 4) d		9/2	-	82 Pb 205m	0.142	1.69426
83 Bi 206	ec/β+	6.243 (± 3) d		6	+	82 Pb 206	1.00	3.758
83 Bi 210	β-	5.012 (± 5) d		1	-	84 Po 210	1.00	1.1613
83 Bi 210	α	5.012 (± 5) d		1	-	81 Tl 206	1.32e-6	5.0364
3	5	Page: 1 / 1						

Download Excel CSV Separator: Semicolon (";") Use field qualifier (")

Datasheets

Radiation search

Nuclide Search | Radiation Search | Advanced Search

- Gamma and X-Rays
- Alpha

Energy: 28 +/- 1 keV
60 +/- 1 keV
102 +/- 1 keV
Emission probability: –
Atomic number Z: Element:
Mass number A: –
Half-life: s – s

Table display options
- Energy uncertainty
- E.P. uncertainty
- Half-life
- FD

Search | Clear

Datasheets

Search returned 19 results, Number of nuclides: 4

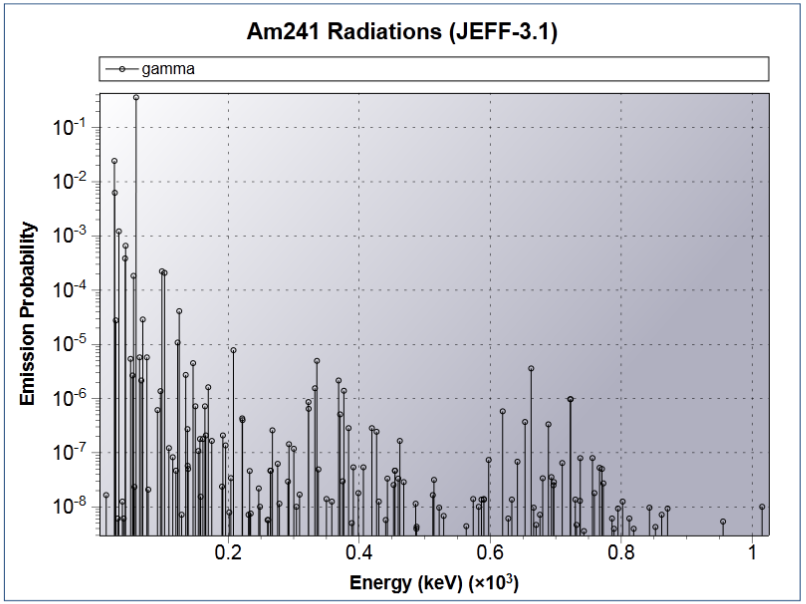
Nuclides	Gamma and X-Rays (keV)	Emission Probability	Half-life
95 Am 241	102.96	0.000209	432.8 (± 7) y
91 Pa 231	102.85	0.00171	32.76 (± 11) ky
91 Pa 231	102.8	0.00015	32.76 (± 11) ky
91 Pa 231	102.1	0.000896	32.76 (± 11) ky
91 Pa 228	102	0.00042	22 (± 1) h
67 Ho 161	101.99	0.000156	2.48 (± 12) h
95 Am 241	101.07	2.07E-05	432.8 (± 7) y
91 Pa 231	60.5	5.5E-05	32.76 (± 11) ky
91 Pa 228	60.3	9.7E-05	22 (± 1) h
91 Pa 228	60.3	9.7E-05	22 (± 1) h
91 Pa 228	59.8	2.8E-05	22 (± 1) h
95 Am 241	59.5412	0.36	432.8 (± 7) y
67 Ho 161	59.24	0.00605	2.48 (± 12) h
91 Pa 228	28.8	0.000152	22 (± 1) h
67 Ho 161	28.69	1.17E-05	2.48 (± 12) h
95 Am 241	28.51	2.77E-05	432.8 (± 7) y
91 Pa 228	28.3	2E-05	22 (± 1) h
91 Pa 231	27.36	0.111	32.76 (± 11) ky
95 Am 241	27.04	0.00626	432.8 (± 7) y
4	19	Page: 1 / 1	

Element: Am Mass: 241

Reference Data | Options | Radiations | Description | Derived Data | Cross Sections | Prompt Gammas

JEFF-3.1 | 8th Table of Radioactive Isotopes

gamma | alpha | discrete e⁻ | X-rays & annihilation



Show graph settings | Download SVG image

Show details

Type	E (keV)	Emission probability
γ	59.5412	3.600e-1
γ	26.3448	2.430e-2
γ	27.040	6.26e-3
γ	33.1964	1.217e-3
γ	43.420	6.59e-4
γ	42.720	3.9e-4
γ	98.970	2.23e-4
γ	102.960	2.09e-4
γ	55.550	1.84e-4
γ	125.310	4.10e-5
γ	69.760	2.88e-5
γ	28.510	2.77e-5
γ	123.000	1.080e-5
γ	208.000	7.81e-6
γ	64.820	5.76e-6
γ	75.920	5.76e-6
γ	51.010	5.40e-6
γ	335.390	4.968e-6
γ	146.550	4.50e-6
γ	662.410	3.600e-6
γ	135.300	2.74e-6
γ	54.080	2.66e-6
γ	67.450	2.2e-6
γ	368.590	2.160e-6
γ	169.560	1.620e-6
1	185	Page: 1 / 8

Download | Excel | CSV | Separator: Semicolon (";")

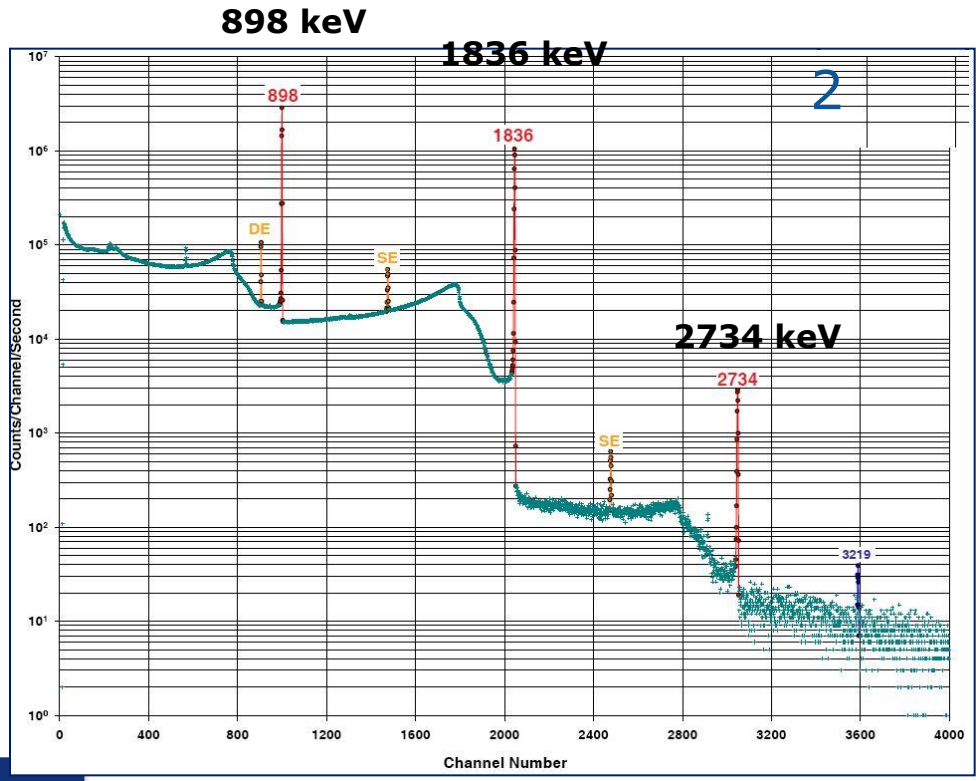
Exercise

Nuclear Data Search

1. Find the nuclides with gamma lines at 81, 303 and 356 keV with an uncertainty of ±1 keV. (Pa-228, Ba-133)

2. Find the Cs isotopes which have a half-life in the range of weeks -100 years.
(Cs-134. Cs-137)

3. See gamma spectrum below – to which isotope does this correspond? (Y-88 or Rb-88)



Dose Coefficients (ICRP 68 & 72)

European Commission

Dose Coefficients, ICRP 68 & 72

ICRP Database Search

Data source	Type	Element(s)	
☑ ICRP 68	☑ Ingestion	◉ Element	Pu
☑ ICRP 72	☑ Inhalation	○ All	

Dose coefficient

Search returned 13 results

Nuclides	ICRP 68 Inhalation $e(50)_{inh}$ (Sv/Bq)	ICRP 68 Ingestion $e(50)_{ing}$ (Sv/Bq)	ICRP 72 Inhalation $e(50)_{inh}$ (Sv/Bq)	ICRP 72 Ingestion $e(50)_{ing}$ (Sv/B
94 Pu 234	2.2E-08	1.6E-10	2.4E-08	1.6E-10
94 Pu 235	2.6E-12	2.1E-12	1.5E-12	2.1E-12
94 Pu 236	1.8E-05	8.6E-08	1E-05	8.7E-08
94 Pu 237	3.6E-10	1E-10	3.9E-10	1E-10
94 Pu 238	4.3E-05	2.3E-07	0.00011	2.3E-07
94 Pu 239	4.7E-05	2.5E-07	0.00012	2.5E-07
94 Pu 240	4.7E-05	2.5E-07	0.00012	2.5E-07
94 Pu 241	8.5E-07	4.7E-09	2.3E-06	4.8E-09
94 Pu 242	4.4E-05	2.4E-07	0.00011	2.4E-07
94 Pu 243	1.1E-10	8.5E-11	8.6E-11	8.5E-11
94 Pu 244	4.4E-05	2.4E-07	0.00011	2.4E-07
94 Pu 245	6.5E-10	7.2E-10	4.3E-10	7.2E-10
94 Pu 246	7.6E-09	3.3E-09	8E-09	3.3E-09
13	Page: 1 / 1			

Download ◉ Excel ○ CSV Separator: Semicolon (";") ☑ Use field qualifier (")

Help:Dose Coefficients (ICRP 68 & 72)

Level: Intermediate

Contents [show]

Introduction

A measure of the hazard of nuclear material is provided by the toxicity and in particular the radiotoxicity arising from its radioactive "quality" rather than the chemical toxicity. The radiotoxicity of a nuclide is determined by its effective dose coefficient $e(T)$, which accounts for radiation and tissue weighting factors, metabolic and biokinetic information. The quantity T is the integration time in years following intake. For adults, the integration time is 50 years, such that the radiotoxicity (in Sievert, Sv) or committed effective dose resulting from intake of a particular nuclide is the product of the effective dose coefficient (units Sv/Bq) and the activity (in Bq) of that nuclide i.e.

Committed effective dose = Activity · $e(50)$.

The two main pathways for intake of a radionuclide are through ingestion and inhalation. Accordingly one can differentiate between the ingestion dose coefficient $e_{ing}(50)$ and the inhalation dose coefficient $e_{inh}(50)$.

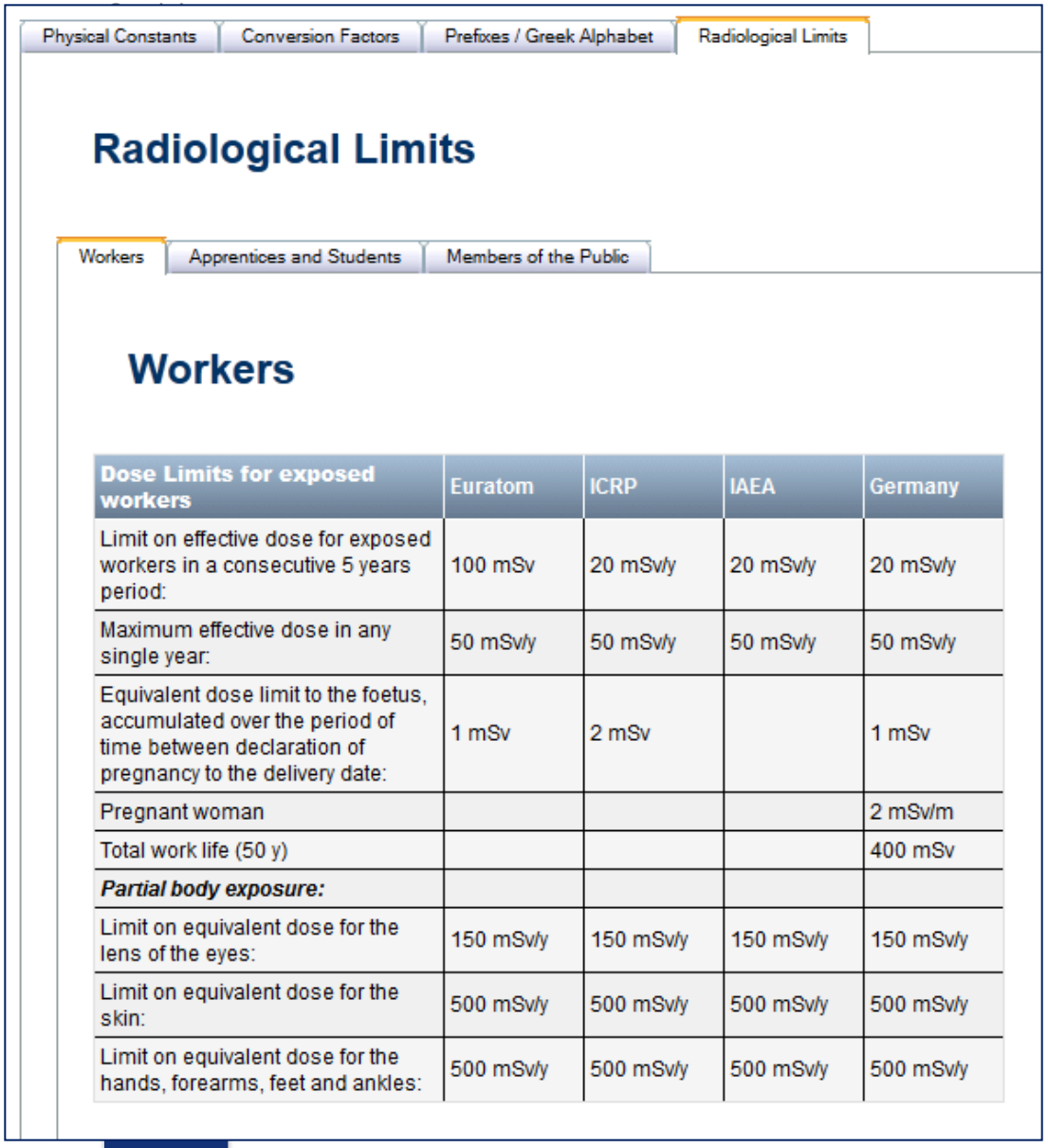
Physical Constants, Conversion Factors, Radiological limits…

Physical Constants | Conversion Factors | Prefixes / Greek Alphabet | Radiological Limits

Physical Constants

Quantity	Symbol	Numerical Value	Uncertainty	Unit	Name In Script
Speed of light in vacuum	c	299792458	0	ms^{-1}	Const_c
Newtonian constant of gravitation	G	6.67428E-11	67	$m^3kg^{-1}s^{-2}$	Const_G
Magnetic constant	μ_0	1.2566370614E-06	0	N/A^2	Const_mu0
Electric constant	ε_0	8.854187817E-12	0	Fm^{-1}	Const_eps0
Planck constant	h	6.62606896E-34	33	Js	Const_planck
reduced Planck constant	$\hbar$	1.054571628E-34	53	Js	Const_planck_2pi
Atomic mass constant	u	1.660538782E-27	83	kg	Const_u
Energy equivalent of atomic mass constant	u	931.494028	23	MeV	Const_u_energy
Neutron mass	m_n	1.674927211E-27	84	kg	Const_mn
Neutron mass	m_n	1.00866491597	43	u	Const_mn_u
Neutron mass	m_n	939.565346	23	MeV	Const_mn_energy
Proton mass	m_p	1.672621637E-27	83	kg	Const_mp
Proton mass	m_p	1.00727646677	10	u	Const_mp_u
Proton mass	m_p	938.272013	23	MeV	Const_mp_energy
Electron mass	m_e	9.10938215E-31	45	kg	Const_me
Electron mass	m_e	0.00054857990943	23	u	Const_me_u

Physical Constants, Conversion Factors, Radiological limits…



Physical Constants | Conversion Factors | Prefixes / Greek Alphabet | Radiological Limits

Radiological Limits

Workers | Apprentices and Students | Members of the Public

Workers

Dose Limits for exposed workers	Euratom	ICRP	IAEA	Germany
Limit on effective dose for exposed workers in a consecutive 5 years period:	100 mSv	20 mSv/y	20 mSv/y	20 mSv/y
Maximum effective dose in any single year:	50 mSv/y	50 mSv/y	50 mSv/y	50 mSv/y
Equivalent dose limit to the foetus, accumulated over the period of time between declaration of pregnancy to the delivery date:	1 mSv	2 mSv		1 mSv
Pregnant woman				2 mSv/m
Total work life (50 y)				400 mSv
Partial body exposure:				
Limit on equivalent dose for the lens of the eyes:	150 mSv/y	150 mSv/y	150 mSv/y	150 mSv/y
Limit on equivalent dose for the skin:	500 mSv/y	500 mSv/y	500 mSv/y	500 mSv/y
Limit on equivalent dose for the hands, forearms, feet and ankles:	500 mSv/y	500 mSv/y	500 mSv/y	500 mSv/y

Fission Yields

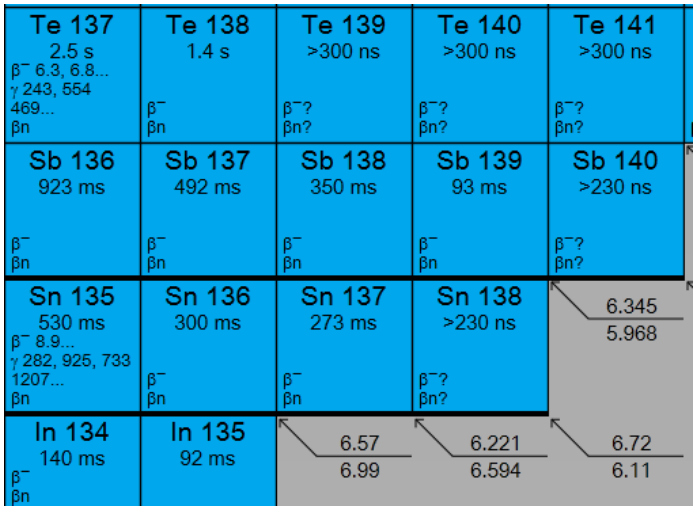
Fission Yield: Number of atoms of a specific nuclide produced per 100 fission reactions

Independent Fission Yields: direct production of specific atoms - decay excluded

Cumulative Fission Yields: direct production + via decay

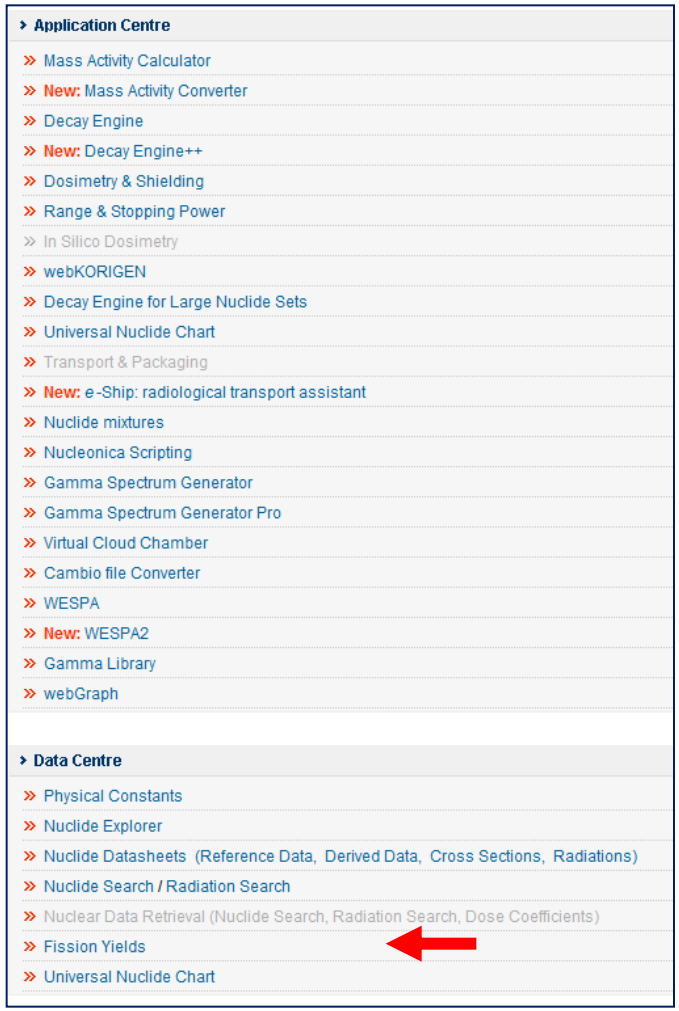
Chain Yield: Atoms of specific isobars (A=const) per 100 fission reactions

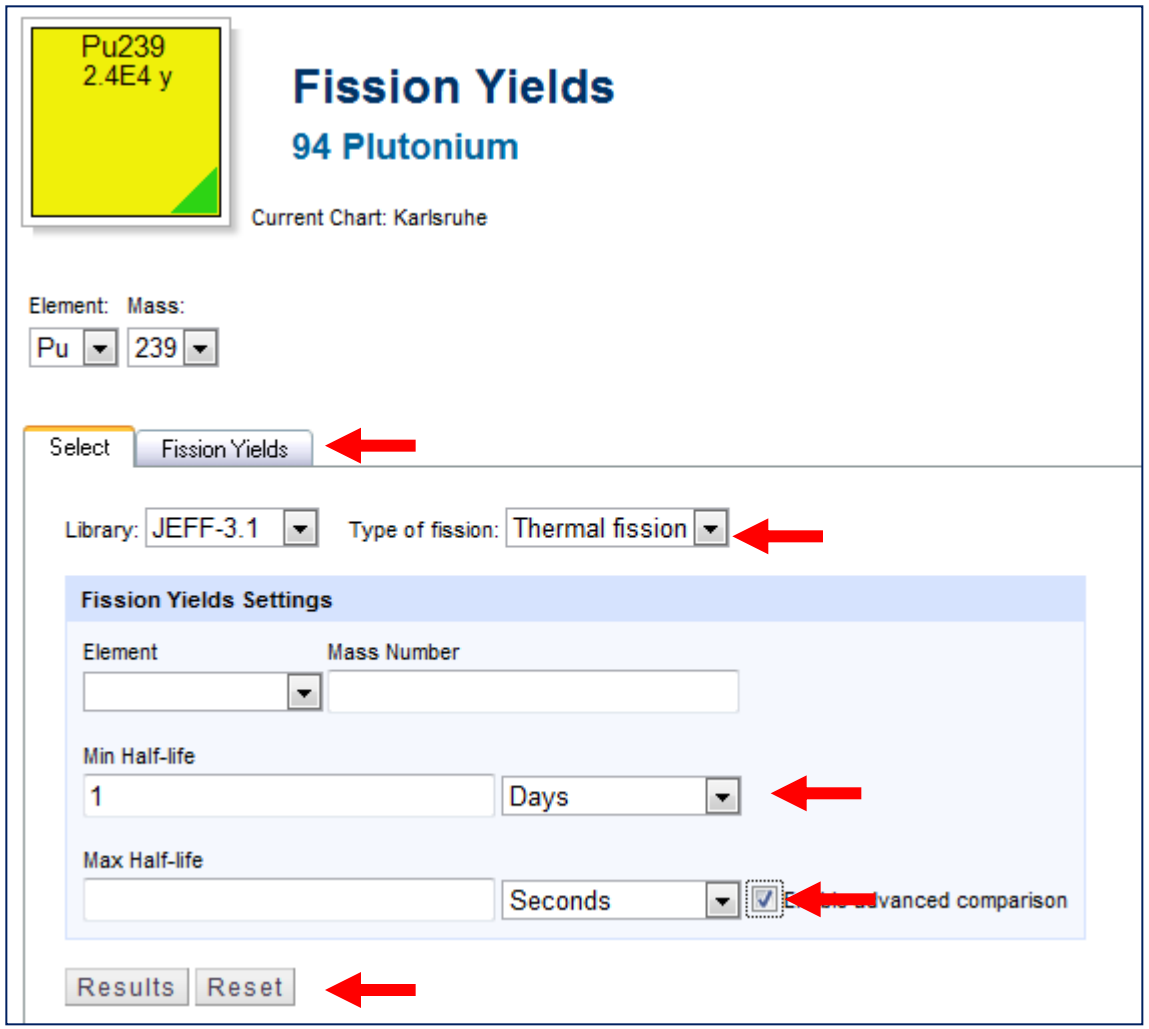
(KNC: U-235 and Pu-239 yields)



European Commission

Fission Yields Module

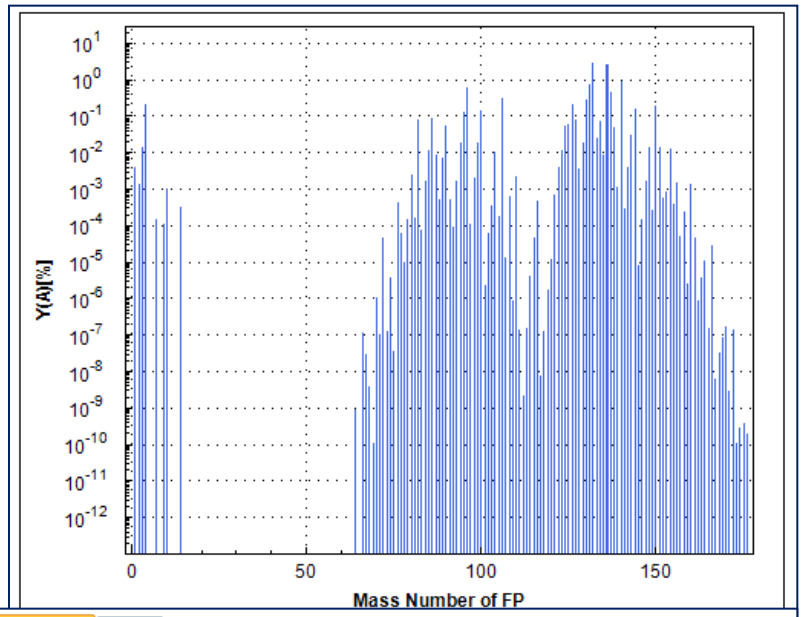




Fission products of Pu-239

Total number of fission products: 306

	Nuclide	Half-life	Independent Yield	Error	Cumulative Yield	Error
Compare	52 Te 132	3.204 (± 13) d	2.94E-02	4.47E-03	5.09E-02	9.36E-04
Compare	54 Xe 136	2.10E+20 (± 0) y	2.70E-02	5.72E-03	6.90E-02	2.53E-03
Compare	56 Ba 140	12.765 (± 15) d	8.76E-03	2.84E-03	5.32E-02	5.86E-04
Compare	52 Te 131m	1.250 (± 8) d	6.85E-03	1.89E-03	9.04E-03	1.45E-03
Compare	40 Zr 96	3.9E+19 (± 9) y	5.82E-03	1.98E-03	4.93E-02	1.53E-03
Compare	55 Cs 137	30.04 (± 3) y	4.57E-03	1.62E-03	6.59E-02	8.03E-04
Compare	44 Ru 106	1.020 (± 2) y	2.98E-03	1.04E-03	4.19E-02	9.21E-04
Compare	52 Te 130	7.90E+23 (± 100) y	2.68E-03	7.95E-04	2.79E-02	6.70E-03
Compare	2 He 4	Stable	2.19E-03	1.18E-04	2.19E-03	8.98E-05
Compare	50 Sn 126	230 (± 14) ky	2.02E-03	3.86E-04	2.64E-03	4.71E-04
Compare	60 Nd 150	2.1E+19 (± 5) y	1.87E-03	5.22E-04	9.75E-03	1.27E-04
Compare	58 Ce 144	285.0 (± 2) d	1.63E-03	6.02E-04	3.75E-02	3.00E-04
Compare	42 Mo 100	9.9E+18 (± 7) y	1.44E-03	5.72E-04	6.84E-02	9.98E-03
Compare	40 Zr 95	64.032 (± 6) d	1.33E-03	4.84E-04	4.95E-02	9.90E-04
Compare	36 Kr 86	Stable	9.19E-04	3.01E-04	7.83E-03	1.85E-04
Compare	34 Se 82	1.21E+20 (± 17) y	8.29E-04	2.30E-04	2.31E-03	4.11E-04
Compare	51 Sb 127	3.85 (± 5) d	7.72E-04	2.50E-04	4.60E-03	2.67E-04
Compare	54 Xe 134	1.1E+16 (± 0) y	6.79E-04	2.40E-04	6.87E-02	3.57E-03
Compare	55 Cs 136	13.03 (± 7) d	5.88E-04	2.07E-04	7.60E-04	2.15E-04
Compare	38 Sr 90	28.79 (± 6) y	5.66E-04	2.07E-04	2.01E-02	5.
Compare	50 Sn 124	1.00E+17 (± 0) y	5.09E-04	1.25E-04	1.26E-03	6.
Compare	50 Sn 125	9.64 (± 3) d	4.99E-04	9.46E-05	5.46E-04	8.
Compare	56 Ba 138	Stable	4.70E-04	1.77E-04	6.11E-02	1.
Compare	58 Ce 143	1.379 (± 2) d	3.09E-04	1.15E-04	4.48E-02	4.
Compare	53 I 131	8.0233 (± 19) d	2.34E-04	8.14E-05	3.72E-02	7.
Compare	40 Zr 94	6.0E+15 (± 0) y	1.98E-04	7.28E-05	4.32E-02	1.
Compare	42 Mo 99	2.7475 (± 4) d	1.91E-04	6.85E-05	6.18E-02	5.
Compare	52 Te 129m	33.6 (± 1) d	1.87E-04	6.55E-05	5.65E-03	4.
Compare	51 Sb 126	12.4 (± 1) d	1.80E-04	6.21E-05	2.22E-04	7.
Compare	54 Xe 133m	2.188 (± 11) d	1.72E-04	6.25E-05	2.16E-03	1.
Compare	1 H 3	12.33 (± 2) y	1.42E-04	1.09E-05	1.42E-04	6.
Compare	61 Pm 151	1.1833 (± 16) d	1.40E-04	4.79E-05	7.76E-03	1.



Comparison of fissioning system | Libraries

Cs-137 for Pu-239 Thermal fission JEFF-3.1 library

S: Spontaneous fission
T: Thermal neutron induced fission
F: Fast neutron induced fission
H: High energy (14 MeV fusion neutrons) neutron induced fission

	JEFF-3.1-Pu239T	Pu239F	U235T	U238F	U233F
Independent Yield	4.57E-03	6.95E-03	7.22E-04	4.36E-05	9.21E-03
Error (I)	1.62E-03	2.48E-03	2.56E-04	1.59E-05	2.83E-03
Cumulative Yield	6.59E-02	6.35E-02	6.22E-02	6.02E-02	6.50E-02
Error (C)	8.03E-04	1.21E-03	6.94E-04	1.52E-03	3.12E-03
Y(A)	6.71E-02	6.45E-02	6.24E-02	6.21E-02	6.58E-02
Error (A)	1.29E-02	1.25E-02	1.25E-02	1.20E-02	1.27E-02

Exercises

Fission Yields

1. Find the thermal neutron fission products of U-235. How many fission products are listed in JEFF? (977)

2. Which fission products have the highest yields? Give cumulative and independent. (Te-134, Xe-134)

3. What is the cumulative fission yield of Cs-137? (6.22E-2 or 6.22%)

Overview

Nuclide Charts

Karlsruhe Chart of Nuclides

Electronic Nuclide Charts in Nucleonica

Nuclear Data Search in Nucleonica

Fission Yields

Thank You